"Megaceros Hibernicus" in Peat

My friend, Dr. Leith Adams, has given it as his opinion that the Irish elk is only found in the clay or marl under the peat, while I contended that some of them occur in the peat, this opinion being formed from reports of finds in the counties of Limerick, Carlow, and Wexford, also from the colour and appearance of the bones; still I could not be positive, as I had not myself seen the bones raised out of the peat. Last week, however, I heard from Capt. Woodrift, Kilowen Inch, Co. Wexford, that he had found an elk's head in the peat, and I went to see it. It was lying on its back altogether in the peat, except some of the points of the horns. The portions in the clay under the peat were quite hard, while those in the peat were soft, but became quite hard a short time after they were taken out.

The "Elk Hole" at Kilowen is a very remarkable place, because, although very small, not 200 yards in diameter, yet at the present time the remains of over ten skeletons of elks have been taken out of it; while in the undisturbed portion of the bog there are probably other skeletons. A few miles to the south-west of Kilowen there is the small bog of Axe, in which the remains of the *C. megaceros* has also been found.

Ovoca, July 8 G. H. Kinahan

Perception of Colour

Happening to be reading out of doors, while the sun was shining on my book, I noticed that patches of weed on the lawn appeared peculiarly conspicuous in their difference of tint from the grass. The same patches of weed close-cropped to the level of the grass were ordinarily scarcely observable from difference of colour. Now, as I looked up from my book—my eyes dazzled with the glare—they appeared to me to have a strong blue tint. My attention thus being drawn to the point, I extended my observations, with the following results, which, if new, will doubtless prove interesting to some of your readers. I found that if the eye was exposed for two or three minutes to the action of a very strong light, *by looking at a sheet of white paper*, while bright sunshine fell on it, the capacity of the eye for perception of colour was curiously modified, under certain conditions. For example: if, on the instant after the exposure of the eye to strong light, as described—solarisation I will call it—flowers of various colours, placed in a shady part of a room were examined, a pink rose appeared the colour of lavender; dark crimson Sweet William, almost black; magenta Snapdragon, indigo; scarlet Poppy, orange; the eye was, in fact, red-blind. After a minute or two, the eye recovered its normal sensibility to red, and the flowers assumed their natural colour.

In order to ascertain that the mal-perception of colour, under the conditions described, was due to the action of strong light on the eye, and not to any other circumstance, I repeated the experiment, allowing the solarisation to take place on one eye only, the other eye being kept shut until the moment of making the observation. I then found, as before, that the solarised eye was red-blind to objects in a subdued light for a minute or two after solarisation, but sensitive to blue, and in less degree to yellow, while the non-solarised eye was perfectly normal in its perception of all the colours. By alternately closing and opening the solarised and non-solarised eye, the difference in colours perceived by the two eyes was extremely striking—the rose was, as seen by one eye, pink, by the other eye, blue. It must be remembered that the effects described were produced when the flowers were observed in a room not strongly lighted.

When a corresponding experiment was made with the flowers *in the sunshine* instead of in the shade, it was found that a reverse effect was produced—that every colour, and red particular, was intenser to the solarised eye than to the non-solarised eye—as was readily seen by alternately shutting and opening them. To the solarised eye a red rose-bud was deep red, to the other eye light red. The red of the poppy was deeper and more vivid to the solarised eye. A calceolaria was orange chrome to the solarised eye, lemon chrome to the non-solarised eye. A viola was dark violet to the solarised eye, a colder tone of blue to the non-solarised eye.

I found that after the insensibility to dimly lighted red and orange (the effect of solarisation) had worn off, a reverse condition succeeded, for example, venetian red, which was a dirty brown, as seen the instant after solarisation, appeared gradually to change to a full vermillion. I found also that portions of the solarised eye that had escaped the solarising action behaved like the non-solarised eye. I leave the explanation of these sligh observations to those within whose special field of study the naturally fall, only remarking that the power of the eye fatigued by solarisation to perceive blue light, and light of nc other colour, under the conditions described, seems to sugges that the eye, like almost all matter sensitive to light, is more sensitive to blue rays than rays of lower refrangibility.

Lancing, July 10 J. W. Swan

WATER-JET PROPELLERS

Very early in the history of steam navigation attempts were made to employ the "hydraulic" or "water-jet" propeller. About 1782 Rumsey began to work in this direction, using a steam-engine to force water out at the stern of a boat, the inlet being at the bow. His experiments are said to have extended over twenty years, but led to no practical result. Another American, named Livingston, applied the same principle of propulsion in a different manner. A horizontal wheel, or turbine, was placed in the bottom of the boat, near the middle of the length, the water was admitted from beneath it, and expelled from the periphery of the wheel through an opening at the after part of the boat. In 1798 a monopoly was granted to Livingston for twenty years by the State of New York, on condition that within a given period he produced a vessel capable of attaining the speed of four miles an hour. This condition was not fulfilled, and, as is well known, the first successful steamers built in this country or abroad were propelled by paddle wheels. This form of propeller alone was employed for nearly forty years, during which period steam-ships increased greatly in numbers, size, and speed, proving themselves well adapted not merely for service on inland and coasting navigation, but also for ocean voyages. Just when the Transatlantic steam service had been successfully commenced by the *Great Western* and *Sirius*, both paddle steamers, the screw-propeller began to threaten the supremacy of the paddle-wheel; and the success of the *Archimedes* in 1840 led to the adoption of the screw in the *Great Britain*, as well as the construction of the screw sloop *Rattler* for the Royal Navy. Soon after came a revival of the water-jet propeller by the Messrs. Ruthven of Edinburgh. In 1843 their first vessel was tried, attaining a speed of about seven miles an hour. Ten years later a fishing-vessel was built on the same principle, and exceeded nine miles an hour. Several other river steamers and small craft were constructed with jet-propellers in the period 1853-65, but they were all comparatively slow, and the plan did not grow into favour either as a substitute for the paddle-wheel or the screw.

There were certain features in the jet-propeller which recommended it to the judgment of many naval officers who had witnessed the trials of vessels so fitted; their influence led the Admiralty in 1865 to order the construction of a small armoured vessel, appropriately named the *Waterwitch*, which was to be fitted with Ruthven's propeller. Admiral Sir George Eliot was one of the principal advocates of a trial of the new system, in which he has always continued to take a great interest. In the German navy, trials of the Ruthven system have also been made on a small vessel named the *Rival*, and experiments of a similar nature have been made in Sweden. At the present time Messrs. Thornycroft are building for the Admiralty a torpedo-boat, to be propelled by water-jets, the trials of which are awaited with interest, since they will furnish another comparison between the performances of the hydraulic propeller and the screw.

The Ruthven system agrees in its main features with the proposal made by Livingston forty years earlier. As an example the arrangements of the *Waterwitch* may be briefly described. Openings are made in the bottom of the ship amidships, to admit the water into a powerful centrifugal pump or turbine, the axis of which is vertical.

The main engines drive the turbine, expelling the water with considerable velocity through curved pipes or passages leading to "nozzles" placed on each side at the level of the water-surface. When the vessel is going ahead the jets are delivered sternwards; if it is desired to move astern the engines are not reversed, but valves are operated in the outlet pipes, and the jets are delivered through the forward ends of the nozzles. These motions of the valves can be made from the deck by an officer in command. If desired, the jet on one side can be delivered ahead, and that on the other side astern, the vessel then turning without headway. This power of control over the movements of the vessel, without reversing the engines, is one of the chief advantages claimed for the system; and it is undoubtedly of value, especially in war-ships. Another advantage claimed for the jet-propeller is the power of turning it on an emergency, into a powerful pump, by which large quantities of water can be discharged from the interior of a ship that has been damaged in action. This latter feature cannot be regarded as of primary importance, however, seeing that modern war-ships are minutely sub-divided into water-tight compartments, and must depend for their flotation upon the integrity of the bulkheads and other partitions, if their skins have been broken through by ramming or torpedo-explosions. A further claim on behalf of the jet-propeller for war-ships is based upon the less risk of disablement in action, as compared with screws or paddle-wheels; and this claim may be admitted. On the other side must be set the fact that all the trials made hitherto in vessels fitted on the Ruthven system have shown a less speed for a given amount of engine-power than would have been obtained with the screw-propeller. It may be urged, of course, that the decrease in speed should be accepted, at least in special cases, in order to secure the undoubted benefit of the hydraulic system. But the general feeling of naval architects and marine engineers is in favour of the use of twin-screws rather than water-jets for war-ships, the duplication of machinery and propellers decreasing the risk of disablement, giving great manœuvring power, and securing higher speed than could be obtained with the jet propeller.

Recently further trials have been made with a vessel built in Germany, from the designs of Dr. Fleischer, who claims to have devised a novel and more efficient system of hydraulic propulsion. A brief notice of the invention appeared in NATURE, vol. xxvi., p. 18; fuller details are to be found in two pamphlets published by the inventor: "Der Hydromotor," and "Die Physik des Hydromotors" (Kiel, 1881). The first of these pamphlets contains a general description of the system, as applied in the *Hydromotor* (a vessel of 110 feet in length, and about 100 tons displacement), a summary of her trials, compared with those of earlier vessels engined on Ruthven's system, and an enumeration of the advantages to be obtained by using jet-propellers instead of screws or paddles. The second pamphlet contains a statement of the experimental and mathematical investigations conducted by Dr. Fleischer in working out his system.

Dr. Fleischer dispenses with a turbine, and allows the steam to act directly upon the water in two large vertical cylinders placed amidships. These two cylinders communicate with the ejecting nozzles which are situated on either side of the keel. In each cylinder there is a "float" or piston of nearly the same diameter as the cylinder, with a closed spherical top; when this float is in its extreme upper position, the cylinder is full of water. Steam is then admitted into the upper part of the cylinder above the float, the latter is pressed down, and the water is expelled through the nozzle-pipe with great velocity. At a certain portion of the stroke, the admission of steam is shut off automatically, the remainder of the stroke being performed during the expansion of the steam, and the velocity of ejection of the water gradually diminishing. At the conclusion of the stroke, the exhaust-valve from the steam space to the condenser is opened, the steam rushes out, forming a partial vacuum above the float, and the water enters, pressing the float up. The entry of the water at this stage is partly through the nozzle, and partly from a separate valve communicating with the water-space of the surface condenser. In order to utilise the vacuum as much as possible, and to increase the effective "head" of water during the down stroke, the cylinders are placed as high as convenient in the vessel. Two cylinders acting alternately were used in the *Hydromotor*, for larger or swifter vessels it is proposed to use a greater number of similar cylinders. As in other jet-propelled vessels valves operated from the deck enable the commanding officer to reverse the direction of outflow of either or both jets, making the vessel move ahead or astern, or turn on her centre. The position of the nozzles in the *Hydromotor* is not so favourable to manœuvring power as in the *Waterwitch*, and the difference in behaviour is likely to be appreciable.

Greater interest attaches to the trials of speed than to those of turning. Unfortunately the records are too meagre to enable a decisive opinion to be formed on the merits of the new system as compared with that of Ruthven. Dr. Fleischer claims that the *Hydromotor* attained a speed of 9 knots with 100 indicated horse-power; but the conditions under which this speed was attained may have differed considerably from those under which measured-mile speed trials are conducted in this country. Any exact comparison of the performances of two steamships with either similar or different systems of propulsion, demands as its basis the elimination of all varying conditions, the determination of the true mean speed, and the calculation of the engine-power corresponding to that speed. Dr. Fleischer may have done all this, but it does not clearly appear in his publications whether he has or not. He distinctly claims for his system a very high "efficiency" as compared with that of Ruthven, but it will be shown hereafter that the formula which he uses is not absolutely correct; and what is more important to note is the circumstance that Dr. Fleischer clearly does not possess the experimental data respecting the resistance offered by the water to the motion of the *Hydromotor* when towed at various speeds, which would enable him to express the true efficiency of the propelling apparatus. On this point a few further remarks may be permittted.

Supposing a vessel to be towed at any speed, and her resistance to be ascertained by a dynamometer, the horse-power expended in overcoming that resistance can be calculated, and. in the terminology of the late Mr. Froude, is styled the "effective horse-power." Next let it be supposed that the vessel is driven at the same speed by her own machinery, and that the "indicated horse-power" in the cylinders is ascertained. The ratio of the "effective" to the "indicated" horse-power expresses the true efficiency of the propelling apparatus, excluding from the account, of course, the efficiency of the boilers. Now what has been said above respecting Dr. Fleischer's figures simply amounts to this: he does not appear to have ascertained the effective horse-power of the *Hydromotor*, and consequently cannot express the true efficiency except as an estimate.

The excess of the indicated horse-power over the effective in any steam-ship is to be accounted for by the waste-work of the mechanism, the waste-work of the propellers, and the "augment" of the tow-rope resistance produced by the action of the propellers. In good examples of screw-steamers the effective horse-power at full speed has been found to vary from 40 to 60 per cent. of the indicated power. Dr. Fleischer claims for the *Hydromotor* a corresponding efficiency of about 34 per cent. at full speed; but not, it would seem, with any certainty.

Passing by this comparison with screw-propelled ships,

the *Hydromotor* may be compared with the *Waterwitch*. She gains upon the latter obviously in the avoidance of much waste-work in the mechanism In the Ruthven system there is necessarily more waste-work in the engines which drive the turbines, and in the friction of the water in the turbines and passages to the nozzles, than has to be incurred in the Fleischer system. On the other hand, in the latter system, there must be some loss from condensation of steam in the cylinders, and the high mean velocity of ejection must be a disadvantage. The considerable variations in the velocity of ejection at different parts of the stroke must also be a disadvantage, as compared with the uniform velocity of delivery from a turbine. Respecting the condensation it is asserted, as the result of experiment, that the losses are exceedingly small, the cylinders being wood-lined, and a layer of hot water being formed below the float. Experienced engineers were scarcely prepared for this satisfactory result, anticipating that more serious losses would occur from the alternate heating and cooling of the cylinders. Of course, experience in such a matter is the true test; but it is to be observed that the *Hydromotor* appears to have very ample boiler-power in relation to the indicated horsepower assigned to her maximum speed. Losses from condensation cannot be estimated from the statement of indicated horse-power. The indicator diagrams which have been published, show a very good performance.

The varying rate of outflow through the nozzles must be a source of disadvantage in the Fleischer system. For the hydromotor it is stated that the *mean* velocity of outflow was about 66 feet per second when the speed of the vessel was about 15 feet per second. We are not informed what was the maximum velocity of outflow; the minimum velocity is said to have exceeded the speed of the vessel. This varying velocity, of course, carries with it a varying thrust, and the hydromotor in this respect must be less favourable to uniform motion of the ship than the screw or paddle or Ruthven propeller, where the thrust can be kept practically constant. With two cylinders this might be more felt than with four or more cylinders, but in all cases the drawback must exist.

The high mean rate of outflow involved in the Fleischer system is contrary to the generally accepted view as to the condition most favourable to efficiency. For a given speed of ship, neglecting the augment of tow-rope resistance which may be caused by the action of the propeller, there must be a certain thrust developed, which will overcome the resistance of the water to the advance of the ship. This thrust in the jet-propeller is measured by the sternward momentum generated in the jets. No matter how the mechanism may be arranged, what has to be done by it is to impart to water which has entered the ship and acquired her forward velocity, a sternward momentum which shall have a reaction equal and opposite to the fluid resistance. Momentum, it need hardly be explained, involves the consideration both of the weight of the water acted upon and of the velocity imparted to it in each unit of time. Nor is it possible to create this momentum in the water expelled from the nozzles without doing waste-work in overcoming frictional and other resistances. The magnitude of this waste work may vary greatly in different examples, and it is difficult to estimate its value apart from experiment. Hence in theoretical investigations, this waste-work is usually neglected, although in practice it is of great importance.

Leaving out of account for the moment this waste-work, and the possible influence upon the efficiency of the propeller exercised by the disturbance produced in the surrounding water by the passage of the ship, it may be well to explain briefly the accepted theory of the action of jet-propellers. This is done in the following equations :—

Let V = the speed of outflow of the jets from the nozzles in feet per second, v = the speed of advance of the ship, A = the joint sectional area of the nozzles in square feet, w = weight in lbs. of a cubic foot of water. Then—

Cubic feet of water acted upon per second $= A \,.\, V$.

Sternward velocity of jets in relation to still water $\Big\} = V - v$.

Thrust, or momentum created per second $\Big\} = \dfrac{w}{g} \,.\, A \,.\, V \,.\, (V - v)$,

where g is the accelerating force of gravity—say 32 feet per second. For sea-water $w = 64$; so that $w \div g = 2$ (nearly) Hence

$$\text{Thrust (in sea-water)} = 2\,A \,.\, V \,.\, (V - v).$$

Under the foregoing assumptions, we also have

$$\begin{aligned}
U &= \text{Useful work of propeller (in unit of time)} = \text{work done in propelling ship.}\\
&= \text{Thrust} \times \text{speed of ship.}\\
&= 2\,A\,V\,(V - v) \,.\, v.\\
W &= \text{waste work in race} = \tfrac{1}{2}\,\textit{vis viva.}\\
&= A\,V \,.\, (V - v)^2.\\
U + W &= \text{total work of propeller} = 2\,A\,V\,(V - v)\,v + A\,V\,(V - v)^2\\
&= A\,V\,(V^2 - v^2).
\end{aligned}$$

$$\text{Efficiency} = \frac{U}{U + W} = \frac{2\,v}{V + v}.$$

From the last of these equations it is seen that the more nearly the velocity of outflow V approaches the speed of the ship v, the nearer will the efficiency approach its maximum value, or unity. Moreover, for given values of speed of ship and *thrust*, if the difference $(V - v)$ between the speeds of outflow and advance is diminished, the area of the outlets must be correspondingly increased. That is to say, if the value of $V - v$ is diminished, the *quantity of water* $(A \,.\, V)$ operated upon must be increased. Now, in general, it has been supposed that the inferior performance of jet-propelled vessels, as compared with screw steamers was due to the small quantities of water acted upon, In the *Waterwitch*, for example, about 150 cubic feet of water were expelled per second, whereas in the rival twin-screw vessel *Viper* more than 2000 cubic feet of water were operated upon per second. In the *Waterwitch* $V = 30$ feet per second, and $v = 15{\cdot}7$ feet per second; so that according to the foregoing formula

$$\text{Efficiency} = \frac{2 \times 15{\cdot}7}{15{\cdot}7 + 30} = \frac{31{\cdot}4}{45{\cdot}7} = 68{\cdot}7 \text{ per cent.}$$

In the *Hydromotor* $V = 66$ feet (mean velocity) $v = 15{\cdot}2$.

$$\text{Efficiency} = \frac{2 \times 15{\cdot}2}{15{\cdot}2 + 66} = \frac{30{\cdot}4}{81{\cdot}2} = 37{\cdot}4 \text{ per cent.}$$

Dr. Fleischer adopts the foregoing equations, so far as they relate to *thrust* and *useful work*, but for the *total work* he uses another formula, and it is here that we venture to think he goes wrong. According to his investigation—

$$\begin{aligned}
\text{Total work} &= \tfrac{1}{2}\ \textit{vis viva} \text{ of issuing streams.}\\
&= \tfrac{1}{2} \times \text{Mass of water delivered per second} \times (\text{speed of outflow})^2.\\
&= \tfrac{1}{2} \times 2\,A\,V \times V^2.
\end{aligned}$$

Hence he writes—

$$\text{Efficiency} = \frac{\text{Useful work}}{\text{Total work}} = \frac{2\,A\,V\,(V - v)}{2\,A\,V \times \frac{1}{2}\,V^2} = \frac{2\,V}{v^2}(V - v).$$

In thus dealing with the total work, instead of using the expression given above, Dr. Fleischer virtually ignores the fact that the vessel is in motion ahead; and that the streams issuing from the nozzles have the velocity V only relatively to her. It is upon this questionable formula for the efficiency that his estimates above-mentioned are based. For example, in the hydromotor at 9 knots, according to Dr. Fleischer—

$$\text{Efficiency} = \frac{2 \times 15 \cdot 2}{(66)^2}(66 - 15 \cdot 2) = 35 \cdot 4 \text{ per cent.}$$

If the same formula is applied to the *Waterwitch*, at 9·3 knots—

$$\text{Efficiency} = \frac{2 \times 15 \cdot 7}{(30)^2}(30 - 15 \cdot 7) = 49 \cdot 9 \text{ per cent.},$$

giving about 20 per cent. less efficiency to that vessel, than is given by the accepted formula first stated.

It has been explained that the assumptions upon which the first formula rests are not fairly representative of the conditions of practice. For example, the deduction therefrom (stated above), that it is advantageous to operate upon larger quantities of water, and to reduce the excess in speed of outflow above the speed of the ship requires an important qualification in practice This deduction would be absolutely correct were it not for the waste-work which has to be done in giving the motion to the water; but in actual practice the growth in that waste work may exceed the gain obtained by dealing with larger quantities of water. The parallel case in a screw steamer is that wherein screws of too large diameter or too large surface may involve so much more waste work on frictional or edgewise resistances, that it is preferable to use smaller screws, which operate on smaller quantities of water, but secure a more economical expenditure of power for a given speed, or enable higher speeds to be attained with a given horse-power. In setting aside the commonly received view, and making trial of a system wherein the mean velocity of the outflowing jets is extremely great, while the quantity of water operated on is small, Dr. Fleischer has made an experiment of the greatest interest to all concerned with steam propulsion. If his figures are accepted it is obvious that his system involves much less waste work than the Ruthven system, between the power indicated in the cylinders and the power accounted for in the outflowing jets. On the other hand, as we have endeavoured to explain, this economy of the Fleischer system does not represent the comparative efficiency of the propelling apparatus: because the high and variable velocity of outflow must involve a considerable amount of waste work in the race. A complete comparison could only be made if in the same vessel, or in two vessels of identical form and with identical boiler-power, there were fitted, first, the Fleischer hydromotor; and secondly, the Ruthven arrangement. Then with the same steam-producing power a careful series of trials would settle the matter conclusively. The Swedes did something of this kind in order to compare the efficiencies of twin-screws and water-jets, with the result that the latter were shown to be greatly inferior. Of course it cannot be expected that Dr. Fleischer would undertake such trials unaided; on the other hand, if his system is put forward for adoption in preference to the Ruthven system, it must, at least, be shown to be more efficient, not only in certain intermediate stages in the operations of giving momentum to the jets, but as a whole. This result does not appear to have been attained as yet, so far as can be judged from the published results of trials. The information which is accessible is not complete, and some of the proposed standards of comparison are open to doubt. It is to be hoped, however, that the zeal and ability which have been displayed already by Dr. Fleischer will be still further illustrated in the continued investigation of the capabilities of his novel system of propulsion.

W. H. WHITE

A RAPID-VIEW INSTRUMENT FOR MOMENTARY ATTITUDES

THE wonderful photographs by Muybridge of the horse in motion and those by Maret of the bird on the wing induced me to attempt the construction of apparatus by which the otherwise unassisted eye could verify their results and catch other transient phases of rapid gesture. Its execution has proved unexpectedly easy, and the result is that even the rudest of the instruments I have used is sufficient for the former purpose; it will even show the wheel of a bicycle at full speed as a well-defined and apparently stationary object. This little apparatus may prove to be an important instrument of research in the hands of observers of beasts, birds and insects, and of physicists who investigate such subjects as the behaviour of fluids in motion.

My object was (1) to transmit a brief glimpse of a moving body, (2) to transmit two or more such glimpses separated by very short intervals, and to cause the successive images to appear as simultaneous pictures in separate compartments in the same field of view.

The power of the eye to be impressed by a glimpse of very brief duration has not, I think, been duly recognized. Its sensitivity is vastly superior to that of a so-called "instanteous" photographic plate when exposed in a camera, but it is of a different quality, because the impression induced at each instant of time upon the eye lasts barely for the tenth of a second, whereas that upon a photographic plate is accumulative. There is a continual and rapid leakage of the effect of light upon the eye that wastes the continual supply of stimulus, so that the brightness of the sensorial image at any moment is no more than the sum of a series of infinitesimally short impressions received during the past (say) tenth of a second, of which the most recent is the brightest, the earliest is the faintest, and the intermediate ones have intermediate degrees of strength according to some law, which an apparatus I shall describe gives us means of investigating. After the lapse of one-tenth of a second the capacity of the eye to receive a stronger impression has become saturated, and though the gaze may be indefinitely prolonged the image will become no brighter unless the illumination is increased.

This being premised, let us compare the sensitivity of the eye with that of the rapid plate in the photographic camera under conditions in which the eye is just capable of obtaining a clear view, let us say during an overcast day in a sitting room whose window does not occupy more than one-thirtieth of the total area of wall and ceiling, which is the light under which most of us habitually write and read. A glimpse under these circumstances of one-tenth of a second in duration, suffices, as we have just seen, to give a clear view, but the sensitive photographic plates sold in the shops as "instantaneous" will not give a portrait in that light under thirty seconds exposure. In other words, the sensitivity of the eye is fully 300 times as great as that of the plate. Of course I am aware that more sensitive plates than these have been made, and I have seen a rapidly revolving wheel photographed under the momentary illumination of an electric spark, but I have never heard of that being done when at the same time the revolving wheel was not perfectly distinct to the eye.

The range of ordinary illumination is very great. The photographer who requires thirty seconds in a dim window-light, would photograph clouds in some minute fraction of a second, showing that the illumination of the latter is fully one thousand-fold greater. If then the eye has been shaded and adapted to a dim light, an object in bright sunshine may require no more than the thousandth part of the tenth of a second to be visible, and in saying this, I am confident that I am underestimating what could be done. Consider what even this means: a cannon ball of ten inches diameter in its mid career travels with a velocity of little more than 1,000 feet in a second; in one ten thousandth of a second it would shift its place through only one tenth of its diameter, and would present to the eye, if it could be viewed under the above-mentioned conditions, the ap-